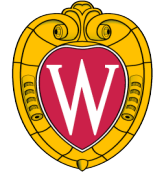




Ophthalmic Dose Compliance Monitor

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Abstract

A device was developed to record the date and time when an eye drop medication has been administered. The final design of the device features an eye drop bottle with two chosen components to facilitate this measurement. First, an ADXL202E dual-axis tilt sensor was implemented to measure when the bottle was inverted past 90 degrees from the vertical. Second, an AD22151 Magnetic Field Sensor was affixed to the cap to measure when the cap was removed. The assumption was made that when both events took place, administration of the medication had occurred. Both the tilt sensor and the magnetic field sensor were integrated into a PIC16F688 microprocessor. A code was written in MikroBASIC to program the microprocessor to recognize the state change for each sensor and create a time stamp for that event. The device was then tested over an eight minute interval while checking for a state change every minute. It was found that the processor successfully recorded and stored when each event took place. A macro was written into an Excel spreadsheet to graph the time of each positive application.

Problem Definition

Statement:

Develop a dose compliance monitor that would record (unknown to the patient) when (date and time) a topical ophthalmic medication was delivered.

Motivation:

- Difficulty in measuring patient compliance
- Testing client's hypothesis:
 - Better treatment of pets than children
- Validate pharmaceutical research/effectiveness

Background:

- Medication monitor – Norell *et al.*
- Compliance monitor – Kass *et al.*

Design Criteria

- Sterility must be maintained
- Sensors and circuitry located on periphery
- Small, lightweight, practically undetectable to patient
- Optimally disposable, <\$5 per bottle to manufacture
- Upload information to computer
- Integrate with different sized bottles
- Quality control mechanism

Cost of Materials

Tilt Sensor	\$8.50
Magnetic Field Sensor	\$2.15
Microprocessor	\$4.00
Battery	\$4.99
Total Cost	\$19.64

Design Components: Results

PIC16F688 Microcontroller

- The logistics handler of the bottle
- Integrates oscillator, sensors and memory
- Registers changes that correspond to dose administration and records, stores event
- Programmed with algorithm
- Contains A/D converter

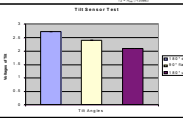
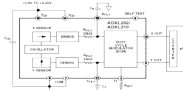


```

main:
  trisa = 1
  portA.TMR1F=0 PIE1 = 1
  ports = 0
  INTCOIN = 0 will jump to interrupt
  procedure on wake up
  cdt = 0
  memloc = 0
  membit = 0
  temp = 0
  do
  cdt = cdt + 1
  if cdt < (interval-1) then
    if app = 0 then
      checkapp()
    end if
  else cdt = 0
    writeapp, memloc, membit
  end if
  
```

Dual-Axis Tilt Sensor

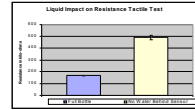
- Small, 5x5x2 mm
- Low Power
- Operates at 3-5 V
- Oscillator detects change in voltages due to degree of tilt
- Test designed to determine voltages at various tilt angles
- Extremely accurate readings



The PIC16F688 was programmed to read the approximate orientation of the bottle by the tilt sensor. Tilted values are represented in the graph. An average of 100 readings was taken for each angle. There is significant error. Error represents standard deviation between readings, based on multiple standard error differences.

Tactile Sensor

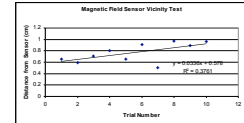
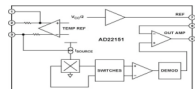
- Detect force applied to medicine bottle
- Resistance most sensitive at tip
- Change in curvature of bottle influences resistance readings
- Test to determine impact of liquid
- Liquid level influences resistance readings



The "Liquid Impact on Tactile Sensor" test was designed to determine if the amount of water in the medicine bottle had a significant impact on the resistance value measured by the tactile sensor. Based on the significant resistance of the test, a subsequent difference in liquid level did not have a significant impact on resistance.

Magnetic Field Sensor

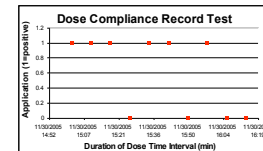
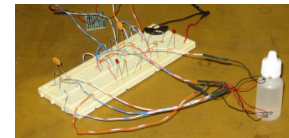
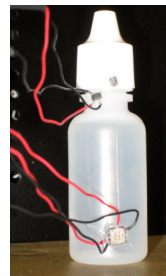
- Simple circuit design to register whether cap is on or off
- Magnet attached to cap, Hall Sensor to bottle
- Test to determine range at which sensor registers
- Magnet connects circuit when within 0.5 – 1 cm of sensor



The magnetic field sensor test was designed to determine how far away the magnet would set off the sensor. Average distance away was 0.50 cm within a range of 0.5 - 1 cm.

Final Design: Progress and Results

- Functions on a two-sensor input
- Magnetic field sensor (Analog Devices) used to determine when the cap is on or off
 - effective within .5 and 1 cm away
- Tilt sensor (Analog Devices) used to measure orientation
 - vertical up (90°) = 2.0951V
 - horizontal (0°) = 2.4064 V
 - vertical down (-90°) = 2.7285 V
- These inputs are integrated into and interpreted by the microprocessor
- A program within the microprocessor records the time at which a medication is delivered
- Code stored on microprocessor converts the inputs into time and date data
- Via a serial port connection, the data will interface onto a computer



Conclusions

After data analysis, it was determined that the most functional design consists of a magnetic field sensor, tilt sensor, and microprocessor combination

- Accomplishes data acquisition with as few parts as possible
- Minimum of two sensors provides elimination of false positives
- Tilt sensor selected
 - Generates measurable differences in voltages
- Magnetic field sensor selected
 - Connects/disconnects circuit at measurable distances
- Tactile Sensors rejected
 - Do not provide useful readouts when the fluid level is below the sensor
- PIC16F688
 - Microprocessor selected
 - Processing power of normal PIC chips
 - 256 bytes of eeprom memory— store timestamps to keep going for 1 month

Future Work

- Further miniaturization, assembly, and final product testing
- Consider cost of professional manufacturing
 - \$50 Miniature circuit chip
 - \$25/hour Assembly and Testing fees
- Select a company to manufacture circuit, assemble, and possibly test final product:
 - Company: Freedom CAD Services
 - Representative: Scott Miller Sales & Marketing
 - Contact Info: scottmiller@freedomcad.com
 - Phone: 603-834-1300, ext 1303
 - www.freedomcad.com

- Company: Bemic Enterprises Inc
- Representative: Adam DeCosta
- Contact Info: adcosta@bemicenterprises.com
- sales@bemicenterprises.com

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Acknowledgments

Authors would like to thank Advisor Walter Block, Client Dr. Christopher Murphy, Dr. Ellison Bentley, Dr. Michael Struck, Dan Yee, David Markovitch, Professor Nicola Ferrier, Analog Devices, and Tekscan.